Building confidence in the Community Ice Sheet Model (CISM) with LIVVkit, the land-ice validation and verification toolkit

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SciDAC Scientific Discovery through Advanced Computing

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Confidence and credibility

Confidence: feeling or belief that one can rely on something
Credibility: the quality of being trusted and believed in

- Verification and validation (V&V) is a set of confidence building techniques.
- V&V is a continuous process tandem to, and essential to, development.
- V&V is not enough! Credibility relies on:
  - Reproducibility
  - Transparency
  - Discoverability

LIVVkit is designed to build user and developer confidence, as well as, scientific credibility

- tests and analyses can be quickly repeated
- results are portable and web-ready
- Integrates easily into the developer workflow
- Nightly builds and tests of CISM (the community ice sheet model)
  - http://blizzard.ornl.gov
- runs on PCs and HPCs with the same interface
- Public code releases on github:
  - Code: https://github.com/LIVVkit/LIVVkit
  - Docs: https://github.com/LIVVkit/LIVVkit/wiki
  - Example: http://livvkit.github.io/LIVVkit/
- private development to protect novel analyses and intelectual property
  - Code: https://github.com/ACME-Climate/LIVV
  - Example: http://acme-climate.github.io/LIVV/index.html

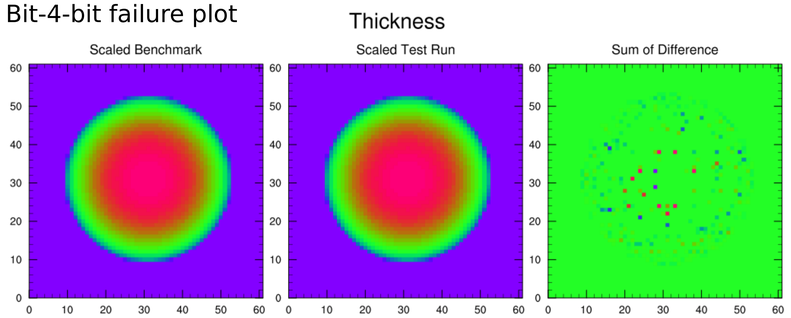
Verification

Software verification — LIVVkit: verification

The process of determining if the software's implementation accurately represents the developers' specifications. This is an **enginnering** problem:

"*Did we build what we intended?*"

Bit-4-bit failure plot



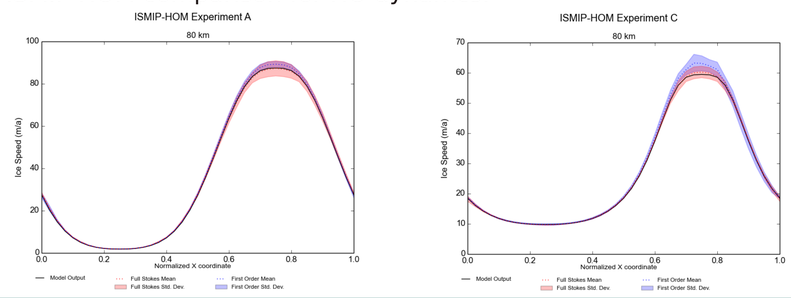
- Failure description with error deatils -- max and RMSE
- Test configuration compairison
- Bit-4-bit analysis of multiple, relevant variables
- Automatic failure plot genration

Numerical (algorithm) verification — LIVVkit: numerics

The process of comparing the approximate numerical solution of the model, or parts of the model, against a numerical benchmark (e.g., an analytical solution or a manafactured solution). This is a **math** problem:

"*Are we sloving the equations correctly?*"

ISMIP-HOM comparison for HO dynamcs:



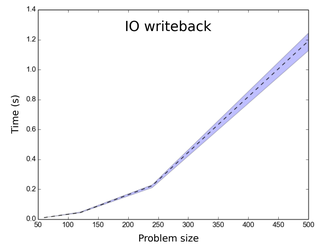
Validation

Software validation — LIVVkit: performance

The process of determining how well the software is able to be used for its intended task. In the case of ice-sheet models, especially for those coupled to a global-climate model, *performance* aspects will be the focus of software validation. This is a **design** problem:

"*Did we build what the users needed?*"

Scaling plot



- Automatically parse GPTL timing files
- Timing summary for multiple simulations -- min, max,and mean
- Automatic scaling plot generation -- strong and weak

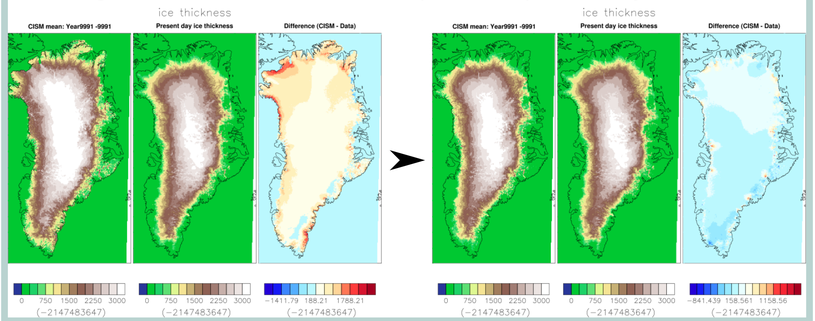
Physical validation — LIVVkit: validation

The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the indended uses of the model. This is a **physics** problem:

"*Are we using the right physics?*"

User example

Jeremy Fyke (LANL) analyzed a CISM 2.0 diagnostic simulation with a validation test he and Lauren Vargo (UNM/LANL) developed for LIVVkit and discovered a bug. Below-left shows the bad simulation with an errant 2.5 km high ice cliff, and below-right show the fixed simulation. All plots were produced by LIVVkit.



LIVVkit

Good Design = Good Tools

Easy deployment

- Internal dependency management
- Automatic website generation

User friendly

- Command line options or saved configurations

Increase productivity

Extensible and maintainable

- Python code base
  - Modular for easy test and feature additions
  - Commonly used by scientists
- Jinja2 for website generation
  - Templated for easy changes

Planned development

Released soon

- Support more CISM dycores
- better performance metrics and plots
- Initial validation tests
- numerics module

Later

- ???
- interactive tables and plots
- Antarctica!
- Support other ice-sheet models

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